

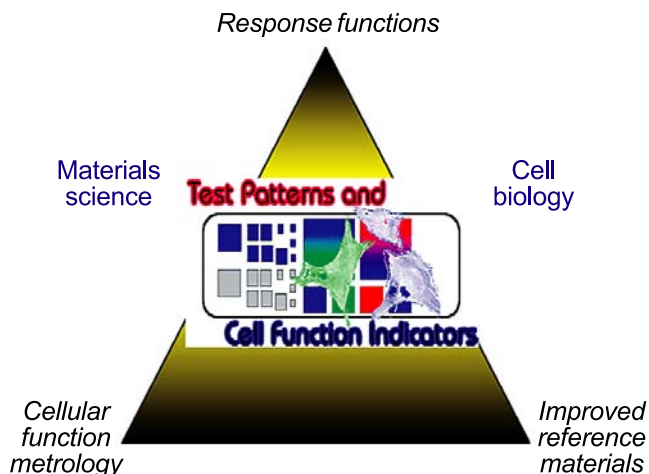
Biomaterials

New materials and devices are radically changing the treatment of injury and disease, yet it is clear that within this rapidly evolving segment of the materials industry, a basic measurement infrastructure does not exist. The Biomaterials Program develops measurement methods, standards, and fundamental scientific understanding at the interface between the materials and biological sciences. For the health care industry, we focus on dental and medical sectors that apply synthetic materials for replacement, restoration, and regeneration of damaged or diseased tissue. Three primary foci exist within this program: biocompatibility, biomaterials characterization, and materials measurements applied to biological systems.

Whether the medical issue involves implanting a hip- or knee-joint prosthesis, a synthetic bone graft, or a tissue engineering scaffold into the human body, one primary issue is biocompatibility. Using our expertise in materials science, we have developed suitable Reference Materials (RM) for investigating biocompatibility and implant suitability. Research has focused on measuring cellular response to powders and bulk materials that are candidates for implants; recently, we produced a realistic wear particle Standard Reference Material (SRM[®] 2880) for bioactivity testing.

Work on quantitative methods of biomaterials characterization includes assays for adhesion, viability, proliferation, and differentiation of bone cells, 3-dimensional structural/functional imaging of tissue in-growth, and biochemical assays to quantify inflammatory responses to synthetic materials. The focus of this effort is bridging the gap between fundamental knowledge and the product development needs in industry. For example, in collaboration with the Chemical Science and Technology Laboratory, we are developing measurement methodologies and reference materials to assess interactions in complex systems of living cells with synthetic materials. The expected outcome of this work includes reference substrates that induce specific cellular responses, and engineered DNA vectors to act as fluorescent reporters of cellular responses.

Another example of our effort to bridge this gap is our collaboration with the dental industry, which is primarily composed of small manufacturers with limited R&D capability. Collaborations with the American Dental Association Foundation (ADAF) develop improved materials and materials measurements techniques, patent and license these inventions, and, most importantly, provide a technical foundation. Research focuses on improved understanding of the synergistic interaction of the phases of polymer-based composites and the mechanisms of adhesion to dentin



and enamel. This approach will ultimately lead to materials with improved durability, toughness, and adhesion to contiguous tooth structure. We also collaborate with the ADAF to develop metrology for the biocompatibility of synthetic bone grafts.

In this era of interdisciplinary research, we provide an added dimension. By taking a physical/mechanical approach to how cells function, respond, and remodel in interaction with synthetic materials, we provide skill sets typically absent in the biomedical community. Mechanical properties issues also arise when considering synthetic bone grafts and tissue engineering scaffolds. Complementing traditional bulk mechanical property measurements, combinatorial approaches are being developed to identify compositions and surface features that affect properties such as biocompatibility and mechanical durability.

Our mechanical property metrology extends further to biological systems that span the range from individual neurons and muscle cells to complete pulmonary arteries. This necessitates the development of unique mechanical testing platforms and application of a materials science approach to understanding integrated properties. Recently, we have developed a bioreactor capable of applying biaxial stresses and allowing monitoring of the stress and strain of a two-dimensional scaffold sheet during tissue growth.

Fundamental to the Biomaterials program is recognition of the need for an integrated systems approach. Collaborations among and between project teams are critical to progress against the ambitious goals of this program.